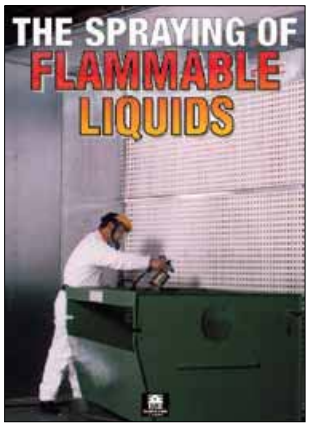
The spraying of flammable liquids



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This book provides information on the hazards of spraying with flammable liquids. It describes preventive and protective measures to reduce the risk of fire and explosion.

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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

Contents

INTRODUCTION

1 Spraying is the most widely used method in industry of applying paints, varnishes, lacquers and other coatings. Many of these coatings are flammable liquids which, when sprayed, may create a flammable atmosphere leading to the risk of fire or explosion.

2 This book provides information on the hazards of spraying with flammable liquids. It describes preventive and protective measures to reduce the risk of fire and explosion.

3 It is aimed at managers and supervisors who control spraying operations. It may also be of interest to trade organisations or associations who may wish to use the guidance as a basis of more specific guidance for their own members.

4 General advice on the handling and storage of flammable liquids is available in several other HSE publications.[1-8] A glossary of terms is provided at the back of the book.

5 This book does not cover the health hazards of paints and coatings although some basic information is given. Advice is available in other HSE publications.[9-15]

6 Where a British Standard is quoted, any other national or international standard that provides an equivalent level of safety is acceptable.

HAZARDS

Fire and explosion hazards

7 The main hazards from the use of flammable liquids are fire and explosion, involving either the liquid or the vapour given off from the liquid. Fires or explosions are likely to occur when vapours or liquids are released into areas where there may be an ignition source, or when an ignition source is introduced into an area where flammable liquids are being used. For example, if spraying is carried out in a workshop where someone is smoking, welding or using unprotected electrical equipment, then the vapour will ignite, causing a fire or explosion. Similarly, if someone takes an ignition source such as a lighted cigarette or an unprotected light into a spraying area, then again fire or explosion may result.

8 In spraying, liquid is converted into a mist of droplets which is directed onto a surface to produce an evenly distributed film of the required thickness and texture. Not all the liquid sprayed is deposited on the workpiece. Over 50% may be lost as overspray or bounceback (see Figures 1a,1b). These vapours may hit other surfaces - walls, floors and clothing - leaving flammable deposits. Even when these deposits are dry, they may still be flammable. If they are ignited a serious fire may result. Contaminated clothes may be easily ignited causing severe burns.

9 Flammable vapours are also released during the drying process and may present a serious fire hazard. Some finishes, particularly lacquers, may contain up to 80% of volatile solvent which evaporates during drying.

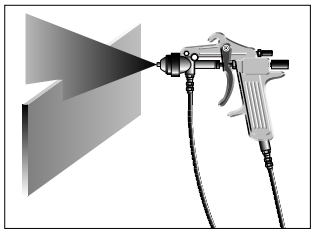

Figure 1a
Example of spraying problem: overspray

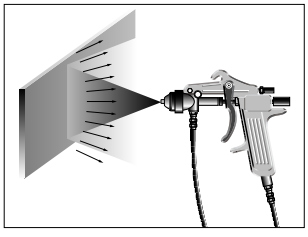

Figure 1b
Example of spraying problem: bounceback

10 Common causes of incidents associated with the spraying process include:

- lack of awareness of the properties of flammable liquids;
- smoking;
- hot work on or close to spray equipment;
- unprotected electrical equipment;
- spillage during handling and cleaning;
- leakage from damaged or poorly maintained pipes, hoses and other fittings;
- flammable overspray deposits on walls, floors and other surfaces;
- contaminated cleaning rags, clothing and other materials;
- inadequate design and installation of equipment;
- inadequate inspection and maintenance.

11 Examples of incidents involving flammable liquids and residues are given at the end of this section.

Health hazards

12 Flammable liquids can pose a health hazard if they are ingested, come into contact with skin or eyes, or if their vapours are inhaled. Information on the health hazards of a particular liquid, and on any specific precautions, should be obtained from the health and safety data sheet or from the supplier. The Control of Substances Hazardous to Health Regulations 1994[12,13] require employers to assess the health risks from exposure to hazardous substances and the precautions needed.

13 Advice on the health hazards associated with the spraying of flammable liquids is outside the scope of this book. However, serious health hazards are associated with the spraying of two-pack paints and lacquers containing isocyanates. These

are often used to achieve hard, durable, easy to clean finishes. In these coatings, isocyanate hardeners or activators are added to liquid resins and pigments to produce a polyurethane film. Vapours and spray mists containing isocyanates are highly irritant to the eyes and respiratory tract, and are reported to be one of the main causes of workplace occupational asthma. People can become sensitised to isocyanates so that even minute concentrations can lead to severe asthmatic attacks. Advice is available in several HSE publications including HSG53 *Respiratory protective equipment: a practical guide for users*[14] and L55 *Preventing asthma at work: how to control respiratory sensitisers*.[15]

Table 1 Incidents involving flammable liquids

A fire started in a spray booth. Overspray residues were ignited by an unprotected light. The fire spread rapidly from the booth to the workroom where flammable paints and thinners were stored.

An operator was spraying small items in a spray booth. Paint residues had accumulated on the fan blades due to lack of cleaning. The fan became unbalanced and struck the casing. Sparks were generated which ignited the flammable residues. The operator was burnt by the flash fire.

An electrician was removing a fan from ducting at a spray booth. He was using an unprotected light, a hacksaw and a portable grinder. The flammable residues ignited and the electrician was badly burned.

The operator was working in a spray booth. He used an open container of thinners to wash the equipment. He knocked the container over onto his trouser leg and shoe. He went into the adjacent room where there were drying ovens. The thinners ignited causing burns to his leg and foot.

A fire started in a spray booth and spread to an adjacent booth. It was started by a spark from a steel scraper which was being used to clean the walls of the booth. The effects were mitigated by a good standard of housekeeping. The fire was extinguished by an automatic sprinkler.

A man was cleaning a spray gun using highly flammable liquid in a cleaner unit for spray guns. The vapour ignited and he suffered burns to his hands. Other employees were smoking nearby.

A man had been mixing HFLs for spraying. While he was wiping up some small spillages of thinners, he was smoking. His clothing caught fire and he was badly burned.

The operator flushed acetone through a spray gun to clean the nozzle. Acetone splashed onto the floor and onto his overalls. As he walked away he noticed flames on his nylon overalls and rubber boots. The spray booth floor was burning. The source of ignition was thought to be static electricity. The spray booth was severely damaged. The operator was lucky to escape without injury.

Two employees were fitting a new pump to the side of a spray booth used for spraying cellulose lacquer. While they were drilling holes, the flammable residue ignited, filling the room with smoke. After a short time there was an explosion which demolished the spray room and caused substantial damage to the structure of the building.

A fire broke out at a spray booth which was being repaired. A contractor was trying to make a hole in the booth using an angle grinder. Sparks from the grinder ignited residues. Damage was extensive because of the large quantities of flammable liquids held in the spray shop, which was completely destroyed by the fire.

LEGAL REQUIREMENTS

14 The Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972[16,17] require precautions to reduce the risk of fires and explosions, where flammable liquids or gases are stored or processed. These precautions include measures to prevent a flammable atmosphere from being formed and to control ignition sources.

15 Under the Management of Health and Safety at Work Regulations 1992[18,19] every employer has a duty to carry out an assessment of the risks to the health and safety of employees and of anyone who may be affected by the work activity. This is so that the necessary preventive and protective measures can be identified and implemented.

16 There are also general duties under health and safety law which are relevant. Further information on legal requirements is given in Appendix 1.

RISK ASSESSMENT

17 HSE recommends a five-step approach to risk assessment:[20]

Step 1: look for the hazards;
Step 2: decide who might be harmed, and how;
Step 3: evaluate the risks arising from the hazards and decide whether existing precautions are adequate or more should be done;
Step 4: record your findings;
Step 5: review your assessment from time to time and revise it if necessary.

18 The particular aims, with respect to the fire and explosion hazards, are:

- to prevent fire and explosion;
- to ensure that people can escape to safety;
- to limit the spread of fire.

19 You will need to find out about the hazards of a paint or coating before use. This information can be obtained from the supplier. All suppliers of hazardous substances must comply with the Chemicals (Hazard Information and Packaging for Supply) Regulations 1994.[21-25] The supplier must ensure that the substance is classified and labelled with the appropriate hazard symbols and the risk and safety phrases. Information in the form of a health and safety data sheet should also be supplied.

20 You will also need to assess the spraying process. These are some of the questions to consider:

- Can the liquid be substituted with a less flammable or non-flammable one?
- Are the vapours controlled and contained within the spray area?
- Is there separation to stop the spread of fire?
- Is the spray area adequately ventilated?
- Are ignition sources controlled?

CONTROL MEASURES

21 You will need to know what is good practice to decide if your precautions and control measures are sufficient. Information on control measures is given in this section. It is advisable to consult your suppliers and your insurers, and to seek the advice of organisations such as the fire authority, the Health and Safety Executive and the Environment Agency.

Substitution

22 Substitution simply means using a less hazardous substance. Flammable liquids may be substituted by less flammable or non-flammable liquids. Water-based coatings are increasingly available and are suitable for many purposes. Before a new material is used, an assessment should be carried out to ensure that other hazards are not introduced.

23 If substitution is not practical, then consideration should be given to reducing the amount of bounceback and overspray. Typical losses range from 30% to 70% depending on the type of spraying system used. An alternative to substitution may be to reduce the amount of vapour released. Your supplier should be able to supply details of expected losses.

24 Although not the subject of this book, there are also environmental requirements. Spraying releases volatile organic compounds (VOC) and particulate emissions which are subject to controls under the Environmental Protection Act 1990.[26-29] For example, metal coating companies that use more than five tonnes of solvent a year are required to register with their local authority for an authorisation to operate. Again, use of water-based coatings or lower-loss systems may be advantageous. Further guidance is available from the Environment Agency, the Scottish Environmental Protection Agency or from local authorities, who together enforce the Environmental Protection Act.

Containment and separation

25 The usual way to control the flammable vapours arising from spraying processes is to use a ventilated spray booth or enclosure. Its purpose is to:

- prevent the escape of vapours into the workplace;
- prevent contamination of the workplace by overspray;
- protect the health of workers;
- provide separation from sources of ignition and to prevent the spread of fire;
- prevent contamination of the workpiece by dust and grease from the work environment.

26 There are many different designs of spray booth. Some are described in paragraphs 54-60. The design of the booth will depend on the articles to be sprayed. An open-fronted bench-type booth is generally appropriate for small articles. Larger items such as cars are usually sprayed in enclosed, walk-in booths. Items may also be sprayed in rooms or spray spaces provided adequate control measures are taken. These measures are described in paragraphs 69-72.

27 A spray booth or enclosure should be of half-hour fire-resisting construction. If spraying is carried out in a partial enclosure, a work area or a spray space, then it should be fire separated from adjoining rooms.

Ventilation

28 The purpose of ventilation is to:

- draw overspray away from the operator;
- control flammable and hazardous vapours;
- collect vapours, droplets and solid particles; and
- filter or wash the air before it is discharged.

29 The ventilation should be sufficient to prevent the formation of dangerous concentrations of flammable vapours. As a rule, the maximum flammable concentration in a spray booth or spray space during normal operation should not exceed 25% of the lower explosive limit (LEL). The lower explosive limit is a property of the flammable material. It is basically the minimum concentration of flammable vapour in air needed to cause a fire or explosion. Most flammable liquids and vapours have an LEL of about 1%. Keeping concentrations below 25% of the LEL provides a suitable safety margin. It may be possible to justify higher levels, up to 50% LEL, for automatic spray booths with gas monitoring. In many cases lower levels will be necessary to satisfy occupational exposure limits.

30 The basic parameter used to specify ventilation requirements is the control velocity. This is the air velocity at the operative's position. The control velocity required depends on the spraying conditions. It should be sufficient to overcome turbulent air movements generated by both the process and random air currents. It should also be sufficient to draw polluted air away from the operator. Air flow or air pressure switches are used to warn if designed exhaust ventilation flow rates are not maintained.

31 A minimum average air velocity of 0.7 m/s at the front of open-fronted booths and enclosures is recommended. If the sprayer works inside a side-draught booth or enclosure, the minimum average air velocity where the sprayer stands should be not less than 0.5 m/s with a minimum measured value of 0.4 m/s. Where a sprayer works inside a down-draught booth or enclosure, air velocity (measured at points around a typical article to be sprayed) should average 0.4 m/s with a minimum measured value of 0.3 m/s.

32 Suppliers of proprietary equipment should advise on the appropriate flow rates for the proposed purpose. If the booth has been constructed 'in-house', advice should be obtained from a competent ventilation engineer. Information may also be obtained from two HSE publications: HSG37 *An introduction to local exhaust ventilation*[30] and HSG54 *The maintenance, examination and testing of local exhaust ventilation.*[31]

33 It is advisable to leave the fan running for several minutes after spraying has finished in order to remove vapours from the system effectively. This can be done with a time delay in the switching circuit of the fan motor. Wet items should not be left in a booth or enclosure when the ventilation is switched off, such as during lunch or tea breaks or at the end of the working day, as a flammable atmosphere may develop.

Control of ignition sources

34 It is impossible to avoid flammable atmospheres during spraying of flammable liquids and so control of ignition sources is essential. Ignition sources include:

- unprotected electrical equipment;
- heating appliances;
- smoking materials;
- welding and other similar hot work activities;
- sparks generated by the discharge of static electricity;
- internal combustion engines.

35 Ignition sources should be kept out of spraying areas at all times. Even when spraying is not taking place, flammable residues, contaminated materials, drying and cleaning operations may still present a fire risk.

36 Hazardous area classification is the method used to identify areas where flammable concentrations of gases or vapours are likely to be present. The aim is to reduce to a minimum acceptable level the probability of a flammable atmosphere coinciding with an electrical or other source of ignition. It is normally used to select fixed electrical equipment but it can also be used in the control of other potential ignition sources such as portable electrical equipment, hot surfaces and vehicles. Advice is available in British Standard BS EN 60079-10: 1996 *Electrical apparatus for explosive gas atmospheres. Part 10: Classification of hazardous areas*[32] and in other publications.[33,34,35]

37 There are three classes of hazardous area or zone: zone 0, zone 1 and zone 2. A zone is an area around a process or activity where a flammable atmosphere may be present. The definitions of the three hazardous zones are given in Table 2. It is advisable to exclude electrical equipment from the spray area. Any electrical equipment that has to be inside the spray area should be designed and constructed for use in a zone 1 or zone 2 according to the hazardous area classification. All other sources of ignition should be removed from the hazardous area.

Table 2 Definition of zones

Zone	Definition
Zone 0	An area in which an explosive gas mixture is continuously present or present for long periods.
Zone 1	An area in which an explosive gas mixture is likely to occur in normal operation.
Zone 2	An area in which an explosive gas mixture is not likely to occur in normal operation, and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

38 Hazardous area classification is not easy. For spray areas, the zones depend on where the spray gun may be used, the level of ventilation, the output of the spray gun, the flashpoint of the spray and its vapour density. The maximum flammable concentration may be determined using an explosimeter or by calculation.[36] It is suggested that if the maximum flammable concentration in normal operation is between 0% and 25% LEL then the area should be regarded as zone 2. If it is above 25% LEL in normal operation then the area should be regarded as zone 1.

39 In many cases a qualitative or 'common-sense' assessment will be sufficient. For example, everywhere in range of the spray gun should be considered as zone 1. For spray booths, the simplest approach is to regard the whole booth interior as zone 1, and to exclude all electrical equipment and other sources of ignition. Adequate lighting of the interior of the booth may be achieved either by using protected lighting, or by allowing light from an overhead fitting to shine through half-hour fire-resistant glass panels sealed into the top of the booth.

40 Figure 2 shows an example of zoning for the manual spraying of an object. It is assumed that zone 1 extends about 2 m horizontally from the source of flammable vapour and upwards vertically from the floor to 1 m above the source, over the whole 2 m horizontal area. Around the zone 1 area, there is a zone 2 area. In the example, this extends another 2 m. There is no zone 2 area above the zone 1 area as flammable vapours are generally heavier than air and will tend to fall to floor level. For this reason, both zones are extended down to floor level.

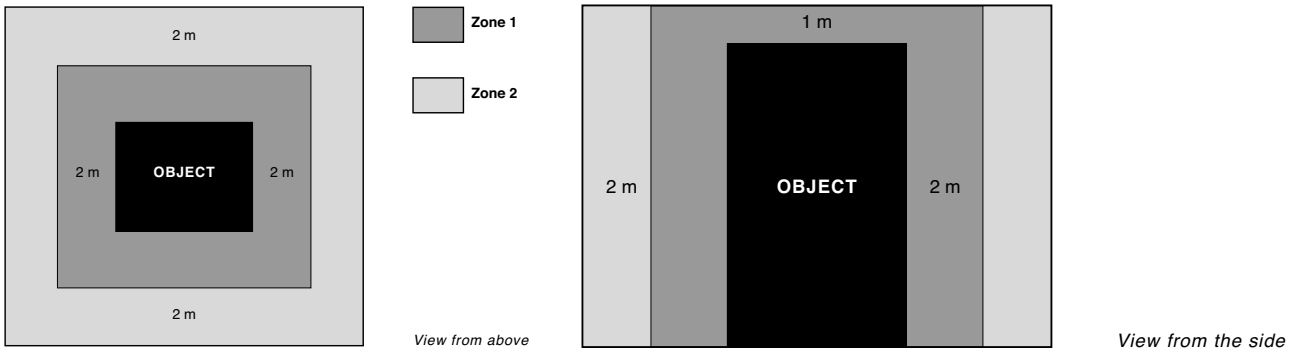

Figure 2 Hazardous area classification

41 In practice, the extent of the zones will depend on local conditions as mentioned in paragraph 38. Again, the simplest approach is to exclude all electrical equipment and sources of ignition from the spray area.

Electrostatic charging

42 Precautions should be taken to prevent vapours being ignited by the discharge of static electricity. British Standard BS 5958[37] gives general advice on the control of static electricity. In particular, non-conducting footwear and clothing made of synthetic fibres can cause incendive electrostatic sparks, especially if they are worn in areas with non-conducting floors. Electrostatic build-up may be reduced by using antistatic footwear[38,39] and antistatic clothing and floors.

SPRAY METHODS

43 In the spray process, liquid is converted into a fine mist of droplets which is propelled towards a surface where an evenly distributed film is formed. The main spray methods are:

- compressed air;
- hydraulic pressure (airless spraying);
- electrostatic.

Compressed air method

44 The commonest method of spraying is the compressed air operated spray gun in which liquid is atomised, in either internal- or external-mix nozzles by compressed air (30-50 psi). In internal-mix nozzles, liquid and compressed air are combined in a chamber inside the nozzle, whereas in external-mix nozzles liquid and compressed air are ejected through separate orifices to combine outside the nozzle. An example of a spray gun is shown in Figure 3.

45 Liquid can be fed to the gun under pressure, under gravity or by syphonic action. The gravity and syphonic methods are suitable for small-scale spraying and use small containers attached directly to the spray guns. For larger scale spraying pressure-fed spray guns are more suitable. The liquid is fed under pressure through a hose connected to either a pressure pot or a pump. Low viscosities are needed and coatings are often thinned with flammable solvents to reduce the viscosity.

Figure 3
A typical spraygun

46 Air-atomised spray guns typically have application rates of 250-700 ml/minute. Losses are typically over 50% because the liquid either does not reach the object or it is reflected from the surface. This reflected material interferes with the spray from the gun nozzle, creating the characteristic spray fog. In the 'mistless' method, the spray is contained within a conical sheath of air which reduces overspray and ricochet.

High-volume low-pressure

47 Transfer efficiencies may be improved by using high-volume low-pressure (HVLP) spray guns. These atomise the liquid coating using reduced pressures (less than 10 psi). The lower velocity air results in a considerable reduction in bounceback and spray fog, with losses of the order of 15-35%. Reducing overspray has many benefits including reducing flammable deposits on surfaces and clothing, and prolonging the lifetime of spray booth filters.

Airless method

48 In airless spraying, liquid is atomised by forcing it through a small orifice (0.1-1.5 mm) at high pressure (typically in the range 50-400 bar). The hydraulic pressure is usually produced by small piston pumps powered by compressed air. The amount of overspray and ricochet may be about 20% as the velocity of the paint droplets falls off rapidly after leaving the nozzle of the gun. The method is limited primarily to applying viscous high-solid heavy-duty coatings to structural steel, because of environmental considerations.

Air coat, airmix and air-assisted airless

49 Liquid is atomised as in the airless method, but at a lower pressure (30-80 bar). The lower pressure reduces the particle speed and the amount of overspray and ricochet.

Hot spray method

50 Increasing the temperature of a liquid reduces its viscosity, giving it better atomisation and flow properties. This effect can be used as an alternative to adding thinners to make a liquid more suitable for spraying. It is normally used with the airless method but may be used with compressed air systems.

Electrostatic method

51 In electrostatic spraying, liquid droplets (or solid particles) are given an electrical charge (typically 60-150 kV) causing them to be attracted to an earthed conductive workpiece. The charge is applied either to the liquid stream before its release or to atomised droplets by passing them through an ionising field. Up to 90% of the finish is deposited on the surface.

52 Electrostatic paint spraying equipment should be designed and constructed to a recognised standard[40,41] to ensure that there is no risk of the operator being subject to an electric shock. Interlock devices may be necessary to prevent access to the booth and the high voltage transformer while the equipment is in use.

53 There is also a possibility of an electrical discharge igniting the flammable vapour. Care is needed to ensure the article being sprayed remains earthed, and layers of paint should not be allowed to accumulate on hanging hooks and rails.

SPRAY AREAS

Spray booths

54 Commercial spray booths and enclosures are widely available. There are many different designs depending on the type and size of articles to be sprayed. You may also construct your own spray booth or enclosure. (See Appendix 2.)

55 Spray booths can be broadly classified by:

- the method of ventilation (side or down-draught air flow);
- the method of removing particulates from the exhaust air (water wash, baffles or dry filters).

Ventilation

Side-draught booths
56 In these the airflow is horizontal, and they can be used in spraying small and medium sized articles and ones which can be rotated on turntables. This is the most common flow direction and takes advantage of the momentum of the spray (which is directed towards the back of the booth). The degree of enclosure can vary but the greater the enclosure the easier it will be to control the overspray.

Down-draught booths
57 This type of booth, with vertical downward ventilation, is used in the spraying of large articles where all-round access is necessary and the use of a turntable is not appropriate. It allows free movement around the article and the operator is never downstream of the aerosol. Air enters the booth through either an open roof or an air replacement system, and is extracted through the floor usually to washing chambers along the sides of the booth.

Filter systems

Water-wash booths
58 In a typical pumped system a water curtain is formed by spraying water onto a deflector plate towards the rear of the booth. Overspray impacts onto the water film and is washed down into a collection tank.

Dry-filter booths
59 Dry filters both remove particles from the exhaust air and distribute the flow evenly throughout the booth. There are two forms of dry filters: the replaceable filter cells of pleated paper or fibre matting which fit into steel wire packed panels; and the disposable automatic-feed roll.

Baffle booths
60 This relies on the overspray striking the front and back surfaces of steel baffles. This type of booth is suitable only where the quantity of liquid is small and intermittent.

Figure 4 Typical spray booth for vehicles

Figure 5 Typical open-fronted spray booth

Ductwork

61 Any ductwork should be at least half-hour fire resisting. It should be as short as practicable and have no sharp bends, as this tends to decrease the air flow and allow the deposition of residues. Locating the spray process near an external wall may reduce the length of duct required to discharge the exhaust air outside the building. Access points for inspection and cleaning inside the ducts may be needed. Dampers should not be fitted in exhaust ducts unless they are essential for balancing the ventilation system.

62 Electric motors for fans should not be situated in the path of flammable vapours. This may be achieved using bifurcated, centrifugal-type or belt-driven axial fans. Motors (even if they are of flameproof construction) should not be sited within the ducts.

63 As a relatively high volume of air will be exhausted, it is important that the room containing the spray process is provided with adequately sized fresh air inlets.

Electrical equipment

64 Electrical equipment, such as compressor motors, switches and electrostatic power packs, should be excluded from within the booth, where possible. Any electrical equipment that has to be inside the booth should be designed and constructed for use in a zone 1 or zone 2 according to the hazardous area classification (see paragraphs 36-41). It should be located to prevent it being covered with flammable residues.

Drying and curing ovens

65 Flammable vapours are also released during the drying process and may present a serious fire hazard. The drying conditions will depend on the type of coating: some will dry at room temperature, others may need curing or baking at higher temperatures. For drying at room temperature, the spray booth or a designated drying or ‘flash-off’ area may be used. Ventilation should be provided to prevent the build-up of flammable vapours.

66 Ovens are used for drying or curing at higher temperature. They may be separate or combined with a spray booth (combi-booth). They should be ventilated to prevent the build-up of flammable vapours. Some are designed to recirculate a proportion of the warm (solvent-laden) air. It is important to ensure that the dampers are positioned to maintain an adequate exhaust flow rate. The vapour concentration may be monitored with gas detectors which can trigger an alarm, emergency ventilation and shutdown, if the concentration exceeds a specified level.

67 There is currently some debate concerning the requirement for explosion relief. Generally, explosion relief should be fitted unless the oven or combi-booth is protected by a gas detection and alarm system. Explosion relief should be properly maintained: it should not be covered, obstructed or nailed down. It should vent to a safe place.

68 No one should enter an oven or booth during the drying or curing cycle. In some circumstances, it may be necessary to lock doors or interlock them with the heating system. The supplier's instructions should be followed.

Spraying in a workroom

69 Sometimes it is impracticable to use a booth to contain the spraying operation, for example when spraying large items of steelwork or aircraft. In this case, spraying may be carried out in a workroom provided adequate health and safety precautions are taken.

70 If the room to be used for spraying is within a building, there should be half-hour fire separation between the spray room and the rest of the building. If the spray area is part of a larger room (for example, a hangar), dividing the room with fire-resistant curtains will define the spraying area and will provide some fire protection.

71 Before spraying, all potential sources of ignition should be removed. Unprotected electrical equipment should be removed or isolated. If there has to be any electrical equipment in the spray room, a hazardous area classification (see paragraphs 36-41) should be carried out to decide the level of protection required.

72 Ventilation should be provided to maintain the concentration below 25% LEL. Monitoring using an explosimeter may be necessary. The use of a spray system, that reduces the quantity of solvent used and the overspray produced, is recommended. Care should be taken to ensure that the ventilation system is effective at low level and anywhere vapours could accumulate.

Spraying in the open air

73 In the past, it was not unusual for spraying, particularly of large items, to be carried out in the open air. This is less common now because better finishes can be achieved indoors, under controlled conditions, and there are also environmental restrictions. Occasionally, outdoor spraying may be unavoidable such as applying protective coatings to large structures. The precautions are similar to those outlined for workshops. All potential sources of ignition should be removed before spraying. The 'natural' ventilation should be checked to ensure it is adequate to disperse vapours. Additional mechanical ventilation may be necessary if the spray area is in a 'sheltered' location or surrounded by walls and other structures. Spraying should not be carried out near building openings or near pits, trenches, basements, etc where flammable vapours could accumulate. Again, the use of

a spray system, that reduces the quantity of solvent used and the overspray produced, is recommended.

Spraying in confined spaces

74 Spraying is often used to apply coatings to the inside of storage tanks, ships' holds and other enclosed rooms and spaces. The dangers associated with spraying in confined spaces cannot be too strongly emphasised. In an unventilated enclosure, a harmful vapour concentration may be formed within a few seconds of starting spraying, and a flammable atmosphere within a few minutes. Therefore, it is essential that those spraying in confined spaces have adequate safety training and are aware of the hazards involved. A formal written entry permit or permit-to-work is always required for entry into confined spaces. Advice on the duties, precautions and safe systems of work when working inside confined spaces is contained in the HSE publication *Safe work in confined spaces*.[42]

75 Mechanical exhaust ventilation should be provided to ensure that the concentration in all parts of the confined space is at a safe level. The concentration of flammable vapour should never exceed 25% LEL and should be maintained preferably below 10% LEL (10% LEL is the safe working limit recommended by the Institute of Petroleum for tank cleaning operations[43]). Vapours from spraying are likely to accumulate at floor level so extraction at this level is essential. The discharge point should be situated in a safe place away from any building, work area or source of ignition. The provision of a correctly designed ventilation system is important even when paint or other highly flammable material is applied by brush or roller.

76 It is essential that any increase in the flammable vapour concentration above the specified limit (preferably 10% LEL) is detected immediately. If operators are wearing breathing apparatus and protective clothing, they may not be aware of increasing levels of vapour. The instrument normally used is a gas detector or explosimeter preferably with an alarm function. Continuous monitoring is recommended although periodic check measurements may be sufficient, once the effectiveness of the ventilation system has been confirmed. Reassessment of the ventilation may be necessary if there are changes in spraying conditions such as if the number of sprayers is increased or a more volatile coating is used. Any person using an explosimeter should have received thorough training in the use of the instrument and in the interpretation of results.

77 Any alarm should be clearly audible to the people in the confined space. On hearing it, they should leave and not re-enter until the vapour levels have fallen to the safe working level. Investigation of the cause of the alarm is advisable as it may indicate a failure or deterioration of the ventilation system. This may be monitored using an air flow detector in the exhaust or the fresh air inlet trunking.

78 Sources of ignition inside the confined space should be prohibited and any lighting used should be protected to a standard suitable for zone 1. Any unprotected equipment used, such as fan motors, compressors, switches and alarms, must be sited in safe areas outside the confined space where they cannot be exposed to flammable concentrations of vapour.

79 It is important to maintain the ventilation within the confined space until the coating is dry and there is no further risk of a flammable atmosphere. Any accumulation of flammable vapours inside the confined space could be ignited by hot work on the outside.

HANDLING AND STORAGE

Mixing

80 Many spray coatings are prepared by mixing several components together. A dedicated mixing area should be used, located in a separate, fire-resistant and well-ventilated room. Ignition sources should be excluded and only suitable electrical equipment should be used.

81 Proprietary mixing systems are available particularly for mixing paints. These reduce handling and storage, and the risk of spills. If manual decanting and mixing is carried out, this should be done over a spill tray, on a bench with a lip.

Spillage

82 Absorbent material should be readily available to soak up spillages. Contaminated rags and other waste materials are a fire hazard; some may spontaneously ignite. They should be kept in a lidded metal container and disposed of safely. The supplier should provide information on disposal methods which meet safety and environmental requirements.

83 Contaminated clothing should be changed promptly, even if it appears to have dried. Flammable vapour can remain in clothing for a long time and it can be easily ignited, for example, by standing too close to a heater or smoking materials.

Storage

84 The quantity of flammable liquids in the workroom should be kept to a minimum. When not in use, containers should be securely closed and stored in a metal cupboard or bin with spillage retention. Larger stocks should be kept in a separate fire-resisting store. Empty drums or cans should be closed and removed from the workroom, or placed in a metal bin pending removal to a safe place. Further advice is available in the HSE publication HSG51 *The storage of flammable liquids in containers.*[3]

85 The Health and Safety (Safety Signs and Signals) Regulations 1996[44] require stores and areas containing dangerous substances to be identified by appropriate warning signs. The hazard diamond symbols, which are widely available, indicate the hazards clearly.

86 Individual containers should be clearly marked to indicate their contents and the degree of flammability. In most cases, containers will be supplied with this labelling as required by the Chemicals (Hazard Information and Packaging for Supply) Regulations.[21-25]

Smoking

87 Smoking should be banned in places where flammable liquids are handled. Notices[44] prohibiting smoking and other sources of ignition should be clearly displayed in these areas. Members of the public or other unauthorised personnel should not be able to wander into spraying, mixing or storage areas.

Removal of residues

88 Flammable residues are a fire risk if allowed to accumulate. Everywhere that flammable deposits accumulate should be cleaned regularly, nominally once a week but more frequently if necessary. Nitro-cellulose residues should be removed by scrapers made from plastic, wood or phosphor bronze rather than those with iron or steel blades. This prevents the creation of sparks during cleaning.

89 For easier removal of residues from the inside of spray booths, the surface may be coated with proprietary products that can be readily peeled away together with the residues. Such coatings are applied to a clean surface, either as a sheet material or as a liquid which can be sprayed or applied by brush.

90 If the spray booth or area is used for spraying different liquids, care should be taken to ensure that the products are not incompatible. Mixing some products may lead to spontaneous combustion. It may be necessary to clean out booths and ductwork, and to replace dry filters before changing over to another material. Examples of potentially dangerous combinations are:

- deposits of lacquers containing nitro-cellulose with finishes such as varnishes, oil-based stains, air-drying enamels and primers which contain drying oils;
- oxidising agents with any organic finishing material.

Spontaneous combustion may also occur if rags are contaminated with residues of paints containing drying oils such as linseed oils.

91 All residues should be disposed of safely, in accordance with the manufacturer's advice.

Cleaning equipment

92 Take care when using flammable liquids for cleaning the equipment, particularly by manual methods. Use safety rinse/dip/bench cans. These cans are normally fitted with a flame arrester and/or self-closing lids. It is preferable to use non-flammable liquids, or liquids with a high flashpoint. The cleaning operation should be carried out in a well-ventilated area or cabinet. To assist cleaning and reduce the amount of solvent required, excess paint should be poured into a separate container before starting the cleaning operation. It is advisable to apply the flammable cleaning solvent using a pump producing a gentle non-jetting or spraying stream of liquid, with flow rates as low as possible. This will prevent the generation of electrostatic sparks. Containers of flammable washings should be removed from the workroom and disposed of safely.

93 There are now several proprietary spray gun cleaning systems available. These systems are fully enclosed and optimise the amount of solvent needed for cleaning. Vapour release into the workplace is reduced, so resulting in health, safety and environmental benefits.

Protective clothing

94 Clothing can become contaminated and impregnated by overspray and bounceback from the spraying process. This may become a fire risk. Clothing worn during spraying should be non-absorbent and electrostatically safe. Contaminated clothing should be removed before smoking or moving into work areas where sources of ignition might exist.

INSPECTION AND MAINTENANCE

95 Health and safety law[18,19,45] requires that plant and equipment, including spray booths and spray areas, should be checked and maintained regularly. This is to minimise health risks and the dangers from flammable liquids. A typical maintenance schedule could include:

- ensuring that airflow or air pressure differential switches are working, to ensure safe ventilation rates are maintained;
- ensuring that air intakes are not obstructed and that discharge vents are correctly sited and in good repair;
- maintaining any interlocks between spray guns and exhaust ventilation;
- replacing filters;
- removing residues;
- repairing damaged spray booth panels to maintain the fire resistance of the unit;
- inspecting escape routes and rescue equipment.

96 All engineering controls should be examined and tested regularly, especially for the exhaust ventilation. Spray booths and ovens should be checked regularly for leaks and examined by a competent person (either an insurance company engineering surveyor or a representative of the supplier) every 14 months. This is to ensure that control of the exposure of those working outside and inside the booth is maintained.

97 Respiratory protective equipment should be carefully maintained. Written records of equipment tests should be kept.

98 Dry filters need regular replacement. The air speed in the immediate vicinity of the sprayer is often the lowest in the booth because of the accumulation of spray deposits on the filter. Monitoring the air speed will indicate when a new filter is needed.

99 The booth should not be used for storage of equipment or materials. As well as increasing the fire hazard, large items such as drums may interfere with the air flow patterns causing recirculation of contaminated air.

100 A major cause of incidents involving spray booths is hot work (welding, cutting, grinding or similar operations). If hot work is carried out on the booth or near to it, then flammable residues and vapours could be ignited. Do not carry out any hot work on or near to a spray system, whether it is operating or not, unless it has been made safe by the removal of all flammable residues and vapours.

INFORMATION AND TRAINING

101 The provision of adequate information and training is a requirement of several pieces of legislation.[18,19,45-48] All employees should be informed of the hazards from the flammable liquids used and stored, and of the need to exclude sources of ignition and heat from designated areas. Those spraying or handling flammable liquids should also receive specific training in both normal operating and emergency procedures. Periodic retraining will usually be needed. The training should cover the following:

- the types of flammable liquids in use, their properties and hazards;
- general procedures for safe handling of liquids and operation of equipment;
- use of protective clothing;
- housekeeping;
- reporting of faults and incidents, including spills;
- emergency procedures, including raising the alarm, and the use of appropriate fire-fighting equipment.

102 There should be written procedures covering the use of substances that are flammable or hazardous to health, and these should be used as a basis for training. Safety representatives should be consulted at an early stage about any health and safety information, training and retraining that is considered necessary.

FIRE PRECAUTIONS AND EMERGENCY PROCEDURES

103 Following the advice in this book will help to reduce the risk of a fire occurring. Unfortunately, the possibility of fire always remains. It is important to have a pre-planned response to such emergencies, including the appropriate actions to be taken in the event of a fire. The main aim is to ensure people can escape to a place of safety.

104 The Fire Precautions Act 1971[49] is enforced by the local fire authority, and for the majority of premises using flammable liquids the necessary provisions will be specified in a fire certificate issued by that authority. The Act requires the following:

- escape routes;
- fire extinguishers;
- a system of giving warning in the case of fire;
- management procedures to ensure that all of the above are available and maintained, and that there is adequate training in their use.

Means of escape

105 Fires in spray booths or workshops tend to develop extremely rapidly. There should be adequate means of escape from enclosed, walk-in booths. Operatives should never be more than 6 m from an exit door. If the booth is located within a workshop or the workshop is a spray area, then there should be adequate means of escape from the workshop. Again, operatives should never be more than 6 m from an exit door. At least one exit door from the workshop should open either directly into open air, or into another part of the building from which there is an exit direct to open air, separated from the spraying area by a fire-resisting construction having at least 30 minutes fire resistance. All exit doors, either emergency or normal use doors, from spray booths or workshops should open outwards.

Fire-fighting equipment

106 Suitable portable fire-fighting equipment should be provided for all spraying areas. The type and location of all such equipment should be agreed with the fire authority. Extinguishers should be to a recognised standard such as BS EN 3[50] or BS 5423,[51] and be suitable for tackling fires involving flammable liquids. The nominal 9 kg dry powder or 9 litre foam extinguisher is recommended. Such a size of extinguisher combines ease of handling with a reasonable fire-fighting capability. People expected to use fire equipment should be properly trained.

107 Fire blankets should also be provided. A fire blanket may be used to extinguish burning clothing by wrapping it around the person who is on fire.

108 In large spraying areas, or large enclosed spray booths, consideration should be given to the provision of fixed sprinkler systems which can be operated either automatically, or manually using a panic-button system. Such systems have on a number of occasions saved spraying areas and reduced the threat to operatives and other personnel on the premises. Automatic fire warning systems and interlocks with the ventilation may also be advisable particularly for automatic spray booths. It is advisable to discuss the installation of a sprinkler system with the fire authority and with the fire insurance company. The fire authority will also

need to discuss their requirements for fire fighting such as water supplies and access for appliances.

Emergency procedures

109 Putting emergency measures into practice at the earliest stage can significantly reduce the impact of an incident on people and premises. A procedure for dealing with fires or spills should be drawn up to cover:

- raising the alarm;
- calling the fire brigade;
- tackling the fire (when it is safe to do so);
- evacuating the premises safely.

APPENDIX 1
LEGAL REQUIREMENTS

Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972

1 These Regulations[16,17] apply when liquids with a flashpoint of less than 32°C and which support combustion (when tested in the prescribed manner) are present at premises subject to the Factories Act, 1961.[52] An exception to the storage requirements of these Regulations applies where a petroleum licence is in force.

2 The Regulations require that precautions should be taken to reduce the risk of fires and explosions, where flammable liquids or gases are stored or processed. These precautions include measures to prevent and manage leaks, spills and dangerous concentrations of vapours and to control ignition sources.

Health and Safety At Work etc Act 1974

3 The Health and Safety at Work etc Act 1974 (HSW Act)[46] requires employers to provide and maintain safe systems of work. They are also required to take all reasonable precautions to ensure the health and safety of employees and anybody else who could be affected by the work activity. Employers and the self-employed also have a legal duty to take care of their own and other people's health and safety.

4 The HSW Act is enforced either by HSE or by local authorities, as determined by the Health and Safety (Enforcing Authority) Regulations 1989.[48] Further advice on these matters is obtainable from local area offices of HSE or the environmental health department of the local authority, as appropriate. Guidance on the Act is also available in an HSE booklet *A guide to the Health and Safety at Work etc Act 1974*.[47]

Management of Health and Safety at Work Regulations 1992

5 Under these Regulations[18,19] every employer has a duty to carry out an assessment of the risks to the health and safety of employees, and of anyone who may be affected by the work activity. This is so that hazards may be identified and the appropriate preventive and protective measures introduced.

6 An Approved Code of Practice *Management of health and safety at work*[19] gives guidance on the provisions of these Regulations. An HSE leaflet[20] 5 *steps to risk assessment* gives simple general advice on the steps involved in the risk assessment process.

The Provision and Use of Work Equipment Regulations 1992

7 The aim of these Regulations[45] is to ensure safe work equipment is provided and is safely used. Under these Regulations employers must ensure that:

- suitable equipment is provided for the work involved;
- information and instruction are adequate;

- equipment is maintained in good working order and repair;
- training is provided for operators and supervisors;
- equipment is safeguarded to prevent risks from mechanical and other specific hazards;
- equipment is provided with appropriate and effective controls;
- maintenance is carried out safely.

8 Regulation 12 is particularly relevant to equipment associated with flammable liquids. It requires employers to ensure that people using work equipment are not exposed to hazards arising from:

- equipment catching fire or overheating;
- the unintended or premature discharge of any liquid or vapour;
- the unintended or premature explosion of the work equipment or any substance used or stored in it.

The Petroleum (Consolidation) Act 1928

9 The Act[53] requires the keeping of petrol and petroleum spirit (except for small specified quantities) to be authorised by a licence, and to be in accordance with any conditions of the licence. The Petroleum (Mixtures) Order 1929[54] extends these requirements to petroleum mixtures which are defined in the Order.

Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996

10 These Regulations[55] describe measures to prevent ignition by equipment and apply both to electrical and non-electrical equipment and protective systems. They apply to all equipment intended for use in potentially explosive atmospheres. The Regulations apply to all new equipment, with a transition period up to 2003. The Regulations define different categories of equipment for use in hazardous areas. The different categories of equipment cater for the different risks in zones 0,1 and 2. Harmonised standards describe detailed methods of complying with the essential safety requirements for equipment. When equipment designed to comply with the Regulations becomes available it will carry the CE mark and the Ex (in a hexagon) mark.

Factories Act 1961

11 This Act[52] defines a ‘factory’ and contains many general and detailed provisions relating to work activities in factories. Section 31(3) contains specific requirements relating to the opening of plant that contains any explosive or flammable gas or vapour under pressure. Section 31(4) contains specific requirements relating to the application of heat to plant that has contained any explosive or inflammable substance. ‘Inflammable’ means able to burn with a flame and is generally taken to have the same meaning as ‘flammable’. ‘Inflammable’ substances and vapours will include flammable liquids and vapours.

Chemicals (Hazard Information and Packaging for Supply) Regulations 1994 (together with subsequent amendments)

12 These Regulations[21-25] are commonly referred to as CHIP. They contain requirements for the supply of chemicals. The Regulations require the supplier of chemicals to:

- classify them, that is identify their hazards;
- give information about the hazards to the people they supply both in the form of labels and safety data sheets;
- package the chemicals safely.

13 Classifying chemicals according to the CHIP Regulations requires knowledge of physical and chemical properties, including the flashpoints of liquids, and of health and environmental effects. Chemicals are grouped into three categories of danger, according to their flashpoints:

- extremely flammable - liquids with a flashpoint lower than 0°C and a boiling point lower than or equal to 35°C;
- highly flammable - liquids with a flashpoint below 21°C but which are not extremely flammable;
- flammable - liquids with a flashpoint equal to or greater than 21°C and less than or equal to 55°C and which support combustion when tested in the prescribed manner at 35°C.

14 Flammable, highly flammable and extremely flammable liquids are all included in the scope of this guidance book. The Regulations are supported by an Approved Supply List containing agreed classifications for some common substances, an approved classification and labelling guide, an Approved Code of Practice on safety data sheets and by the HSE guidance publication *CHIP 2 for everyone.*[25]

Electricity at Work Regulations 1989

15 These Regulations[56, 57] impose requirements for electrical systems and equipment, including work activities on or near electrical equipment. They also require electrical equipment which is exposed to any flammable or explosive substance, including flammable liquids or vapours, to be constructed or protected so as to prevent danger. Advice is given in *Electricity and flammable substances: a short guide for small businesses.*[58] Electrical systems and equipment should be earthed to a recognised standard such as BS 7430.[59]

Control of Substances Hazardous to Health Regulations 1994

16 These Regulations[12,13] require employers to assess the risks arising from hazardous substances at work and to decide on the measures needed to protect the health of employees. The employer is also required to take appropriate action to prevent or adequately control exposure to the hazardous substance.

17 Substances covered by the Regulations include carcinogenic substances and those which, under the Chemicals (Hazard Information and Packaging for Supply) Regulations 1994,[21-25] are labelled as very toxic, toxic, harmful, corrosive or irritant. The Regulations also cover dusts, where present in substantial quantities, and those substances assigned occupational exposure limits. Flammable liquids normally have toxic or harmful properties which bring them within the scope of these Regulations.

Confined Spaces Regulations 1997

18 These Regulations[60] require that no person shall enter a confined space to carry out work for any purpose unless it is not reasonably practicable to achieve that purpose without such entry. If work is undertaken inside a confined space, there should be a safe system of work to ensure that the work is carried out safely

and without risk to health.

Fire Precautions Act 1971

19 This Act[49] controls what have become known as the 'General Fire Precautions', covering the means of escape in case of fire, the means for ensuring the escape routes can be used safely and effectively, the means for fighting fires, and the means for giving warning in the case of fire, and the training of staff in fire safety.

20 The Act allows the presence of flammable liquids to be taken into account when considering general fire precautions. The Act is enforced by the fire authorities and further guidance can be found in a Home Office publication entitled *Fire Precautions Act 1971. Guide to fire precautions in existing places of work that require a fire certificate. Factories, offices, shops and railway premises,*[61] and other publications.[62, 63]

Safety Representatives and Safety Committees Regulations 1977

21 Under these Regulations,[64] where trade union safety representatives exist, employers should consult them about the development of health and safety measures. Where these Regulations do not apply, employers are still required to consult directly with the employees, or through their representatives about health and safety arrangements, under the Health and Safety (Consultation with Employees) Regulations 1996.[65]

APPENDIX 2
FIRE-RESISTING STRUCTURES

1 HM Chief Inspector of Factories has issued Certificate of Approval No 1 for storerooms, process cabinets or enclosures, workrooms, cupboards, bins, ducts and casings, which are required to be fire resisting under the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972.[17] Spray booths may be regarded as a process cabinet or similar enclosure. The main requirements are summarised below. The requirements for ducts and casings are also given.

Cupboards, bins, cabinets and similar enclosures

2 The materials used to construct each side, top, floor, door and lid should:

- if tested in accordance with BS 476[66] Parts 20 and 22 (or previously Part 8) be capable of satisfying the integrity requirement of that test for at least 30 minutes;
- provide an internal surface to the enclosure with a surface spread of flame and heat release classification of Class 0 (as defined in Approved Document B[67] issued in connection with the Building Regulations 1991[68]);
- be fastened together in such a manner, using fastenings (including any hinges) that are of high melting point (in excess of 750°C), that:
    - the entire enclosure, if tested in accordance with BS 476 Parts 20 and 22 (or previously Part 8), would not come apart for at least 30 minutes;
    - the joints are made, bonded or fire-stopped to prevent or retard the passage of flame and hot gases;
    - the structure is sufficiently robust that its integrity will not be impaired by any reasonably foreseeable accidental impact;
- be sufficiently durable that if coated with residues from any spillages, that these can be removed without impairing the structure's fire resistance.

Ducts, trunks and casings

3 Ducts, trunks and casings should:

- be such that if tested in accordance with BS 476[66] Parts 20 and 22 (or previously Part 8) they would be capable of satisfying the integrity requirements of that test for at least 30 minutes;
- provide an internal surface to the enclosure with a surface spread of flame and heat release classification of Class 0 (as defined in Approved Document B[67] issued in connection with the Building Regulations 1991);
- be supported and fastened in such a manner, using supports and fastenings that are of high melting point (in excess of 750°C) that:
    - the structure plus its supports, if tested in accordance with BS 476 Parts 20 and 22 (or previously Part 8) would not collapse or come apart for at least 30 minutes;
    - the joints are made, bonded or fire-stopped to prevent or retard the passage of flame and hot gases;

- the structure is sufficiently robust that its integrity will not be impaired by any reasonably foreseeable accidental impact;

- be sufficiently durable that if coated with residues, these can be removed without impairing the structure's fire resistance.

Examples of fire-resistant materials

4 Some examples of floor, wall and door construction that will provide a standard of half-hour fire resistance are:

Floors

- Plain edge boarding on timber joists not less than 38 mm wide with a ceiling of 12.5 mm plasterboard and 12.5 mm gypsum plaster.
- Tongued and grooved boarding not less than 16 mm thick on timber joists and not less than 38 mm wide with a ceiling of 12.5 mm minimum of plasterboard and a skim coat of gypsum plaster.
- Plain edge boarding on timber joists not less than 38 mm wide with a ceiling of timber lath and plaster, the plaster at least 16 mm thick, covered on the underside with a 12.5 mm thickness of plasterboard.

Walls

- 100 mm brick (unplastered).
- 50 mm woodwool slabs plastered at least 12.5 mm thick on both sides, framed construction (non load-bearing).
- Steel or timber studding with 12.5 mm Portland cement plaster, Portland cement/lime plaster or gypsum plaster on metal or timber lathing (non load-bearing conditions only).
- Steel or timber studding with 9.5 mm thick plasterboard on each side with the exposed facing of the boarding plastered with 5 mm thick neat gypsum plaster (non load-bearing conditions only).
- Where existing walls or partitions are not fire-resisting constructions, the standard can be achieved by adding 12.5 mm plasterboard; ensure that the joints between the overlap are formed over the supporting framework or otherwise suitably constructed.

Doors

- Fit: The door should be reasonably straight and true, and lie flush against the stop when closed. The gap between the door edge and the frame should not exceed 3 mm.
- Door frame: Should have a rebate or stop not less than 25 mm deep. Existing planted stops may be replaced or additional material screwed or pinned and glued on.
- Door furniture: One pair of metal hinges, all parts of which are non-combustible and have a melting point not less than 800°C.
- Glazing: Any plain glazing should be replaced by, or backed with, 6 mm reinforced glass not exceeding 1.2 m^2 in area and fitted with solid wood beading not less than 13 mm in cross-section.
- Flush doors*: 6 mm wallboard cover to both sides of the door. The fixing to be 32 mm screws at approximately 300 mm centres, or annular nails at approximately 200 mm centres, driven into solid timber.

- Panel, framed, ledged and braced doors*: Protection as for flush doors to both faces of the door. Alternatively, if protection against fire is needed from one side only, then 9 mm insulating board fixed to room-risk side of the door, as above, with the panels first made up with tightly fitting cutouts of plasterboard or solid wood.

Electrical equipment

- Unprotected electrical equipment must be kept outside spray booths.
- Install lights outside booths and shine them through fixed and sealed fire-resisting wired glass panels.
- Use only explosion-protected electrical equipment inside the booth.

* The importance of fixing cannot be overemphasised. Additional material mustbe so fixed to the existing door that, under condition of fire where thermal movement is likely to take place between the door and protective material, the screws or nails are not stressed so they are pulled out.

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The future availablility and accuracy of the references listed in this publication cannot be guaranteed.

GLOSSARY

Auto-ignition temperature: The minimum temperature at which a material will ignite spontaneously under specified test conditions. Also referred to as minimum ignition temperature.

Combustible: Capable of burning in air when ignited.

Enforcing authority: The authority with responsibility for enforcing the Health and Safety at Work etc Act 1974[46,47,48] and other relevant statutory provisions.

Fire-resisting: A fire-resisting element of construction is one which would have at least the stated period of fire resistance (relating to integrity, insulation and stability/load-bearing capacity as appropriate) if tested, from either side, in accordance with British Standard 476.[66] In addition:

- where two or more elements of construction together provide separation, the junction between them should be bonded or fire-stopped to prevent or retard the passage of flames or hot gases, thus giving effective fire separation between the rooms or spaces on either side;
- elements of construction should be such that their fire-resisting properties are not impaired by everyday wear and tear. Extra protection, for example crash barriers, reinforcing plates or wearing strips, may be required where mechanical damage is foreseeable;
- the standard of fire-resistance relevant to the storage of flammable liquids is that which will allow adequate time, in the event of fire, for the alarm to be raised, for people to escape and for fire fighting to be put in hand. The standard is not intended to afford protection from a complete burn-out of the storage installation.

Flame arrester: A device consisting of an element, a housing and associated fittings which is constructed and used to prevent the passage of flame. Most flame arresters consist of an assembly containing narrow passages or apertures through which gases or vapours can flow but which are too small for a flame to pass through.

Flammable: Capable of burning with a flame.

Flammable liquid: For the purpose of this book, 'flammable liquid' means a liquid with a flashpoint of 55°C or below and stored at a near atmospheric pressure, except a liquid which has a flashpoint equal to or more than 21°C and less than or equal to 55°C and, when tested at 55°C in the manner described in Schedule 2 of the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972,[16] does not support combustion.

Flammable range: The concentration of a flammable vapour in air falling between the upper and lower explosion limits.

Flashpoint: The minimum temperature at which a liquid, under specific test conditions, gives off sufficient flammable vapour to ignite momentarily on the application of an ignition source.

Hazard: Anything with the potential for causing harm. The harm may be to people, property or the environment, and may result from substances, machines, methods of work or work organisation.

Hazardous area: An area where flammable or explosive gas or vapour-air mixtures (often referred to as explosive gas-air mixtures) are, or may be expected to be, present in quantities which require special precautions to be taken against the risk of ignition.

HFL: Highly flammable liquid.

Incendive: Having sufficient energy to ignite a flammable mixture.

Lower explosive limit (LEL): The minimum concentration of vapour in air below which the propagation of a flame will not occur in the presence of an ignition source. Also referred to as the lower flammable limit or the lower explosion limit.

Non-combustible material: A material that fulfils the criteria for non-combustibility given in BS 476[66] Part 4: 1970. Alternatively, a material which, when tested in accordance with BS 476 Part 11: 1982, does not flame and gives no rise in temperature on either the centre or furnace thermocouples.

Risk: The likelihood that, should an incident occur, harm from a particular hazard will affect a specified population. Risk reflects both the likelihood that harm will occur and its severity in relation to the numbers of people who might be affected, and the consequences to them.

Risk assessment: The process of identifying the hazards present in any undertaking (whether arising from work activities or other factors) and those likely to be affected by them, and of evaluating the extent of the risks involved, bearing in mind whatever precautions are already being taken.

Upper explosive limit (UEL): The maximum concentration of vapour in air above which the propagation of a flame will not occur. Also referred to as the upper flammable limit or the upper explosion limit.

Vapour: The gaseous phase released by evaporation from a material that is a liquid at normal temperature and pressure.

Zone: The classified part of a hazardous area, representing the probability of a flammable vapour (or gas) and air mixture being presen

Further information

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